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Subject: Contract No. 605
Task Order No. 13

Enclosure: Final Report on the Miniaturized Antenna Tuner

Gentlemen:

Pursuant to the requirements contained in subject task order, enclosure (1) is forwarded for your information and files.

Should there be any questions concerning the information herein supplied, please direct your communication to the writer.

Yours very truly,

[redacted]

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Contract Administration

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Final Report on the Miniaturized Antenna Tuner

INTRODUCTION

It is the purpose of this document to summarize the electrical properties of the two miniaturized antenna tuners recently delivered and to make recommendations as to how a further degree of miniaturization might be realized on future models.

SUMMARY OF ELECTRICAL PROPERTIES

The miniaturized tuner was designed to operate over the frequency range of 6 to 18 MC in conjunction with transmitters having a power output of up to 10 watts. Since the physical size was to be compatable with a transistorized transmitter developed concurrently by the customer, miniaturization was a major design consideration. The over-all dimensions of the tuner were 1 1/4" high x 2 3/8" wide x 4" deep, including the operating controls which were recessed for protection.

The curves of figure 1 and 2 present the calculated matching range of the tuners as determined by Storches graphical method.* The 6 MC impedance of several of the "Typical" radiating structures which were tested are also shown in figure 1. It can be seen from these curves that the area of match for most frequencies is large enough to include the impedance of most of the antennas measured in the lab.

The efficiency of each tuner as a function of frequency was measured using a 300 ohm resistor as a load. The results of these tests are shown in figure 3, and as can be seen from this figure, the efficiency ranged from 49% to 78%

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*"Design Procedures for Pi-Network Antenna Couplers," Leo Storch, Proceedings of the IRE, December, 1949, pp. 1427-1432.

depending on the frequency. These values are considered quite reasonable considering the physical size of the tuner and the tight time schedule in which it was built.

The tuner was designed to handle 10 watts of average power. Tests on the two units which were delivered revealed that the units could handle 10 watts quite adequately. The maximum power capability of these units was not however established. Subsequent tests conducted on a unit constructed from spare and reject parts from the first units indicates that these tuners can probably handle 20-25 watts quite safely.

RECOMMENDATION FOR FURTHER MINIATURIZATION

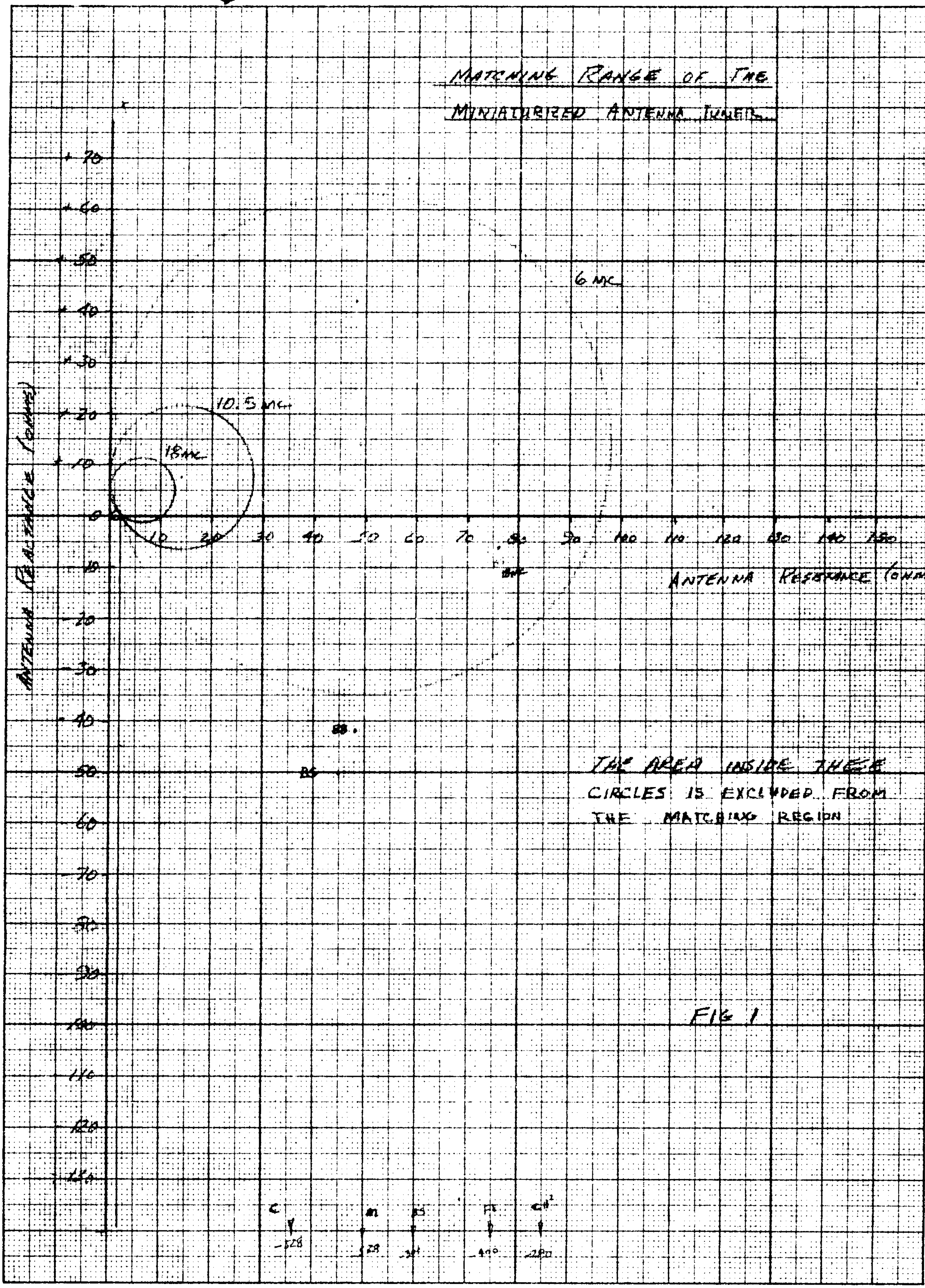
One of the barriers to further miniaturization of the tuner is the problem of designing a small, wide range, high Q inductor. The air cored rotary inductor used in the two delivered tuners represents the minimum practical size reduction for this technique since further size reduction will result in an undesirably low Q. Likewise a conventional slug tuned coil does not appear likely to offer a solution since a wide range of inductance (about 10:1) and a low value of minimum inductance (about .25μh) are required. A solution which does appear promising, however, is a core which incorporates both brass and iron tuning elements. Due to the high permeability of the iron, a large inductance can be obtained in a small space. With the brass portion of the core inserted, a reduction of the inductance occurs due to the shorted turn secondary effect of the brass slug. Using this technique (i.e. varying the insertion of both the iron and brass slugs) inductance ratios as high as 30:1 can be obtained. It is felt that power levels on the same order (i.e. 25 watts) as the previous air core inductor can be handled by the iron and brass elements and the unloaded Q of the inductor should increase, resulting in a more efficient tuner.

Further size reduction should also be possible in the capacitor switching module for the shunt arms of the matching network. The tuner in its present form utilizes commercially available seven and ten position switches to select the required value of shunt capacity and employs a single and different capacitor for each setting. If, then, the individual capacitors employed at the lower capacity settings could also be utilized to add up to the high capacity setting, a further saving in space could be realized. This solution would be the development of a seven and a ten position, progressively shorting switches using printed circuit techniques for successively connecting the individual capacitors in parallel. A further saving in space could be accomplished by eliminating the individual protective coatings from the capacitors and potting all of them as a unit. These modifications should result in at least a 20% volume reduction of the capacitor switching module.

The use of thin film techniques for the noise generator and smaller components in the bridge circuitry would also reduce the total size. The feasibility of constructing the noise generator by thin film techniques was demonstrated during the present program. The thin film units were not employed, however, since their reliability had not been established. The reliability of earlier thin film noise generators has been studied, and their use in future tuners appears quite promising.

Although the delivered tuners were miniaturized, certainly the ultimate size reduction has not been obtained; however, utilization of the techniques mentioned above along with high density packaging would result in total volume reduction of at least 25% and possibly as much as 50% can be expected.

MATCHING RANGE OF THE MINIATURIZED ANTENNA TUNER



THE AREA INSIDE THESE CIRCLES IS EXCLUDED FROM THE MATCHING REGION

FIG 1

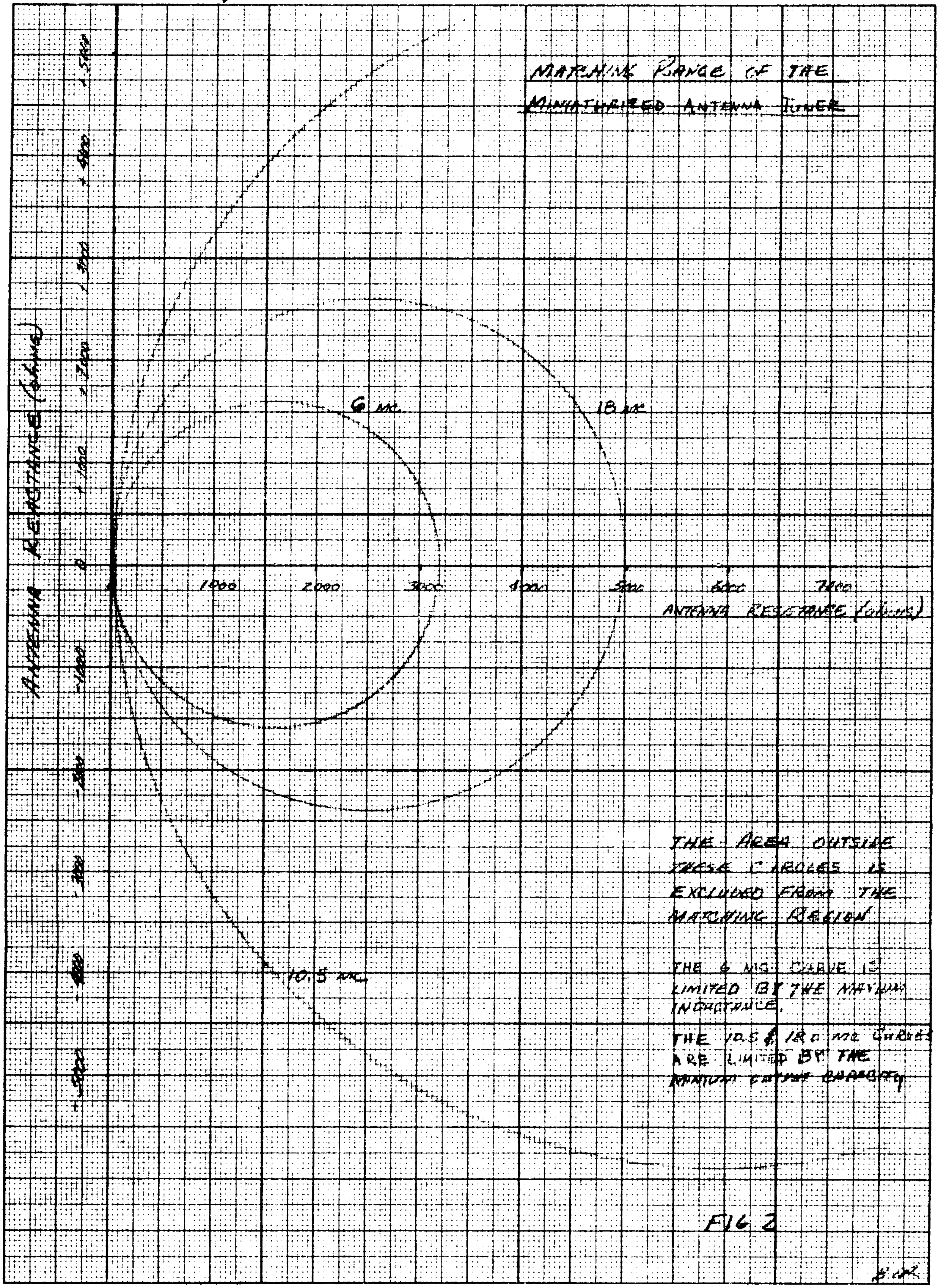

MATCHING RANGE OF THE
MINIATURIZED ANTENNA TUNER
ANTENNA REACTANCE (ohms)
6 MC.
18 MC
10.5 MC
1000
2000
3000
4000
5000
6000
7000
ANTENNA RESISTANCE (ohms)
THE AREA OUTSIDE THESE CIRCLES IS EXCLUDED FROM THE MATCHING REGION
THE 6 MC. CURVE IS LIMITED BY THE MAXIMUM INDUCTANCE.
THE 10.5 & 18.0 MC CURVES ARE LIMITED BY THE

FIG 2

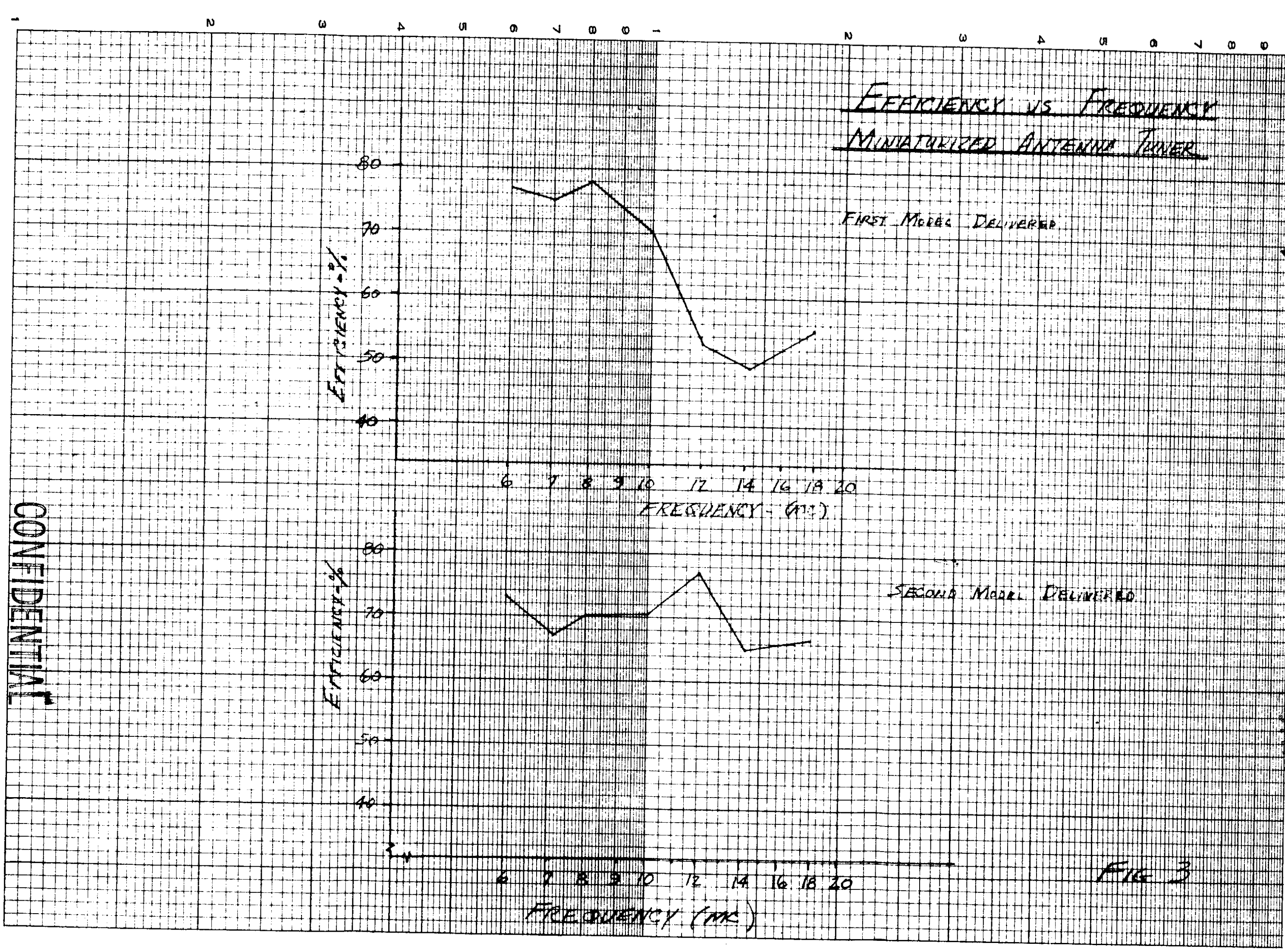

EFFICIENCY VS FREQUENCY
MINIATURIZED ANTENNA TUNER
FIRST MODEL DELIVERED
SECOND MODEL DELIVERED
EFFICIENCY - %
FREQUENCY - (MC)
FREQUENCY (MC)
80
70
60
50
40
6
7
8
9
10
12
14
16
18
20

FIG 3